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REFORMING INDIA'S TECHNOLOGY POLICIES: THE IMPACTS OF LIBERALIZATION ON SELF-RELIANCE AND WELFARE

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Reforming India's Technology Policies:

The Impacts of Liberalization on Self-Reliance and Welfare

by

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IRIS Summary

To varying degrees over the past three decades, Indian policymakers have used the rhetoric of "technological self-reliance" to justify the adoption of a closed technology'policy, a set of measures supposedly designed to shield Indian firms from foreign influences in order to induce them to generate new technologies on their own. The various elements of this closed technology policy--the adoption of a weak patent regime, the regulation of technology purchase licenses, and the limitation of foreign direct investment--are in the process of being removed as part of India's current set of policy reforms. Of concern to many Indian policymakers is whether these regime changes will inhibit the development of an indigenous innovative capability, sacrificing long-run self-reliance in exchange for what are perceived by some to be dubious short-run benefits. On the other hand, those more favorable to the reform process are concerned that as the pressures from the policy reforms mount, short-sighted policymakers may again revert to a closed technology policy, hampering Indian firms from becoming competitive internationally,

This paper reviews the history of India's technology policies from independence to the present. The historical record indicates that while "self-reliance" has always been a prominent theme in India's political arena. alterations in India's technology policies were always precipitated by foreign exchange crises. This historical tendency must be reversed if the present reforms are

to bc sustaincd. Currcnt prcssurcs on the fcderal budget are already threatening the reform process. Since regulating the activities of foreigners is often politically appealing and frequently appears to save on foreign-exchange in the short-run. Indian policymakers will undoubtedly be tempted to revert to a closed technology policy as they have in the past.

This paper argues that such temptations must be resisted on the basis of both theoretical and empirical evidence. On the theoretical level, this paper analyzes the optimal policies for less developed countries in the areas of patenting, foreign direct investment, and technology licensing. These issues are extremely complicated, but there is no clearcut justification for adopting any feature of India's closed technology policy, and such measures may very well be welfare-reducing. On the empirical level, the paper uses the results from several recent studies to demonstrate that abandoning the closed technology policy will cause very little loss in R&D and will result in large increases in private profits. While the change in social profits cannot be calculated, it would take a large divergence between private and social profits to reverse the conclusions.

In short, there is little theoretical justification for maintaining a closed technology policy, and empirically it appears that there are large gains in productivity to be had from liberalization without any significant loss in "self-reliance." While such gains are intrinsically valuable in their own right, they will have the additional benefit of expanding the tax base and alleviating the current pressures on the federal budget, thereby helping to sustain the present reforms. As India's painful economic transition continues, Indian policymakers should see an open technology policy as part of the solution, rather than as part of the problem.

Reforming India's Technology Policies:

The Impacts of Liberalization on Self-Reliance and Welfare

I. Inrroduccion

Achieving technological self-reliance in the industrial sector has been a chief objective of India since its independence. To varying degrees over the past three decades, the government of India has pursued this goal through a "closed" technology policy designed to shield Indian firms from foreign influences. It was hoped that by limiting access to foreign technology, Tndisn firms would learn to generate innovations on their own and would in this sense be-technologically self-reliant. The three key features of this closed technology policy were: 1) the adoption of a relatively weak patent regime, 2) the limitation of foreign direct investment (FDI), and 3) the regulation of technology purchase (TP) licenses. While India's closed technology policy has been particularly restrictive, India is by no means alone amongst less developed countries (LDCs) in utilizing a closed technology policy. Members of the Andean Pact enacted similar policies in the 1970s, and no less a technological force than Korea pursued, albeit to a lesser degree, all three aspects of India's closed technology policy.

As part of its current economic reform package, India has relaxed its restrictions on FDI and TP licenses, and stronger patent protection may be on the horizon following the agreement reached at the Uruguay Round of the GATT negotiations. Of concern to many Indian policymakers is whether these regime changes will inhibit the development of an indigenous innovative capability, sacrificing long-run self-reliance in exchange for what are perceived by some to be dubious short-run benefits. On the other hand, those more favorable to the reform process are concerned that as the pressures from the policy reforms mount, short-sighted policymakers may again revert to a closed technology policy, hampering Indian firms from becoming competitive internationally. Unfortunately, there is very little evidence as to whether or not any feature of India's closed technology policy promotes or hinders indigenous K&U, the usual measure of innovative efforts. Furthermore, even if *it* were known that such policies stimulate domestic R&D, this would not be sufficient to demonstrate that such policies are desirable.

While it is not possible to resolve all of the issues surrounding India's closed technology policy, this chapter uses both theoretical and empirical evidence to argue that it would be unwise for Indian policymakers to revert to a closed technology policy. On the theoretical level, the optimal technology policies for less developed countries are analyzed in the areas of patenting, foreign direct investment, and technology licensing, concluding that there is no clear justification for adopting any feature of India's closed technology policy. On the empirical level, although a complete computation of the social costs and benefits is not possible, using recent estimates from Basant and Fikkert (forthcoming) and Fikkert (1994b), policy simulations demonstrate that the loss of indigenous R&D from the policy reforms will be small, while the gains in terms of increased private profits will be large. In other words, India does not appear to be sacrificing its long run self-reliance as it abandons its closed technology policy, and the resulting gains in profitability could provide the immediate growth which India needs in order to make the current policy reforms sustainable. Panicking as the pressures of the reform process mount by reverting to previous tcchnology policics would choke off a very promising source of growth, namcly thc importation of foreign technology.

The rest of the chapter is organized as follows. Section II reviews the history of India's closed technology policies from independence to the present. Section III reviews the theoretical arguments for and against adopting each feature of a closed technology policy, Section IV presents the empirical evidence concerning the effects of a closed technology policy on R&D. Section V uses some recent empirical results to conduct policy simulations which quantify the effects of abandoning India's closed technology policy on both R&D and private profits. Finally, Section VI concludes the chapter with some comments.

II. The History of India's Technology Policies: The Promotion of Long-Run Self-Reliance or Short-Term Crisis Management?[1]

A. The Period of General Liberalization: 1948- 1965

Given India's experience with colonialism, it is not surprising that at the time of independence Gandhi was eager for India to become self-reliant in the invention and production of as many goods and services as possible. These sentiments were reflected in Nehru's First Industrial Policy Resolution in 1948 which declared that FDI would be regulated to ensure that majority ownership and effective control of firms would remain in Indian hands. Nevertheless, Nehru's Foreign Investment Policy Statement in 1949 gave no indication of regulating FDI. The political turmoil associated with partition was inhibiting nervous domestic investors from starting many new enterprises, so foreign investment was seen as necessary for supplementing domestic capital and technology.

Furthermore, needing hard currency as a result of the foreign exchange crisis of 1957, the Indian government actually began to encourage FDI by lowering corporate taxes on income and royalties, signing an agreement with the United States regarding currency convertibility, sending

[1]This section relies heavily on Kumar (1990).

out missions to advertise India to potential investors, and setting up the Indian Investment Center with foreign branches to facilitate investment in India.

Throughout this time period, FDI was seen as a means to acquire not only foreign capital but also superior foreign technology. Hence, most collaborations consisted of foreign firms acquiring assets in Indian firms in exchange for the foreign firms' provision of capital and improved technology to the domestic firms. Hence, the open policy with regards to FDI can be seen as open with regards to TP also.

There were no significant changes in India's patent legislation during this period, the laws in force being inherited from the system established by the British.

B. The Restrictive Phase: 1966- 1979

A foreign exchange crisis in 1966 created a desire to reduce all flows of funds abroad. Amongst other things, it was felt that remittances of dividends, profits, royalties, and technology licensing fees had to be severely curtailed. This crisis, coupled with India's long-standing goal of self-reliance, was used to justify the adoption of the closed technology policy.

The restrictions on TP licenses and FDI began in 1966 when the government broke down industries into three categories: 1) industries in which the government believed indigenous technological capabilities were sufficient so that no FDI or TP licenses were permitted at all; 2) industries for which TP licenses were permitted but no FDI was allowed; and 3) industries in which indigenous capabilities were particularly lacking so that both FDI and TP licenses were permitted.

Even if a firm was in an industry eligible for TP, an industry in either group 2 or 3 above, the firm would still have to get approval for its specific technology contract from a wide range of review boards. Any of these boards could reject the contract on the basis of the cost of the technology, the availability of local substitutes, the technology's appropriateness, or the impacts that the technology import would have on the development of indigenous R&D capabilities. Furthermore, there were restrictions on the terms of the contracts themselves. Royalties were limited to 3-5 percent of sales and were subject to a 40 percent tax. The maximum life of the contract was reduced from 10 to 5 years, and renewals were difficult to obtain. Technology sellers were forbidden to include restrictions on the Indian firms' exports of goods produced with the licensed technology unless the seller had affiliates in the country to which the Indian firm desired to export. The sellers' trademarks could not be used within India. And there were to be no restrictions on the Indian firms' rights to sublicense the technology.

Unlike the previous period, there was an effort made during this era to unbundle foreign technology and financing. Whenever possible, technology was to be acquired directly through licensing contracts rather than as part of a package deal involving both technology and foreign capital. In this manner it was hoped that Indian firms would acquire only necessary foreign technology and in such a way that domestic ownership of the firms would be promoted. By 1977, only 10 percent of the technology licensing agreements involved any foreign equity participation.

Attempts to curtail foreign influences were continued in 1970 with the adoption of a weaker patent regime, which was hailed as a prototype for other LDCs.[2] The elements of this new regime included: a reduced scope of coverage for each patent, making it easier to "invent around" patented inventions; a system of compulsory licensing; a reduction of the maximum

[2]The new patent regime was not implemented until April, 1972.

length of patent life from 16 to 14 years in most areas and to only 7 years in drugs, food, and medicines; a limitation of patents in drugs, food, and chemicals to a specific product produced by a specific process, meaning that the drug or chemical formula itself was not subject to patent protection on its own; an increase in the fees for application and renewal: and more stringent granting procedures.

The new regime seems to have severely reduced the number of patents taken out by foreigners in India, while the number of patents taken out by Indians has remained relatively constant. The overall effect has been a drastic reduction in the total number of patents in force from over 41,000 in 1968 to just over 17,000 in 1979 (Bagchi et al. 1984). While this drop may have been due to a number of factors such as the limitations on FDI and the overall stagnation of the Indian economy, it seems plausible that the new patent regime has been a major factor.

There are several ironies about India's adoption of a weak patent regime. First, a "closed" patent regime may be very "open" in some senses. While weakening the protection for foreign inventions may discourage foreigners seeking to sell their products and technologies to India, it also opens up the opportunity for freer access to foreign technology through the legalized imitation of spillovers.[3] In other words, the overall effect of a weaker patent regime on the access of Indian firms to foreign technology cannot be ascertained a priori. However, it appears that access to foreign technology per se does not seem to have been the primary motive behind the adoption of a weaker patent regime. Rather, the overriding concern seems to have been that the government wanted to reduce the payments for such technology.

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[3] As will be discussed in later sections, it is actually not clear whether a weak patent regime promotes or reduces international spillovers due to the possibility of "demonstration effects" from the increased working of foreign technology on Indian soil after a patent regime is strengthened.

It is also ironic that the Indian government reduced patent protection for both foreign and domestic inventors when it claimed that it was trying to promote indigenous R&D. Economists have long argued that a weak patent regime lowers the ability of firms to appropriate the returns from their R&D, so a strong regime should raise firms' R&D above the laissez-faire level.[4] Given this, it is a mystery as to why the Indian government adopted a weaker patent regime for both foreign and domestic inventors, especially when providing strong domestic and weak foreign protection was a legal viable option.[5] Again, it appears that stimulating R&D, i.e. promoting technological self-reliance, was secondary to the more immediate concern of reducing payments to foreign inventors who were granted monopoly rights by the pre-1970 patent regime.

In 1974, another round of legislation further restricted FDI. The Foreign Exchange Regulation Act (FERA) required companies to dilute their foreign equity participation to 40 percent or less. Exceptions permitting foreign participation between 51-74 percent were given to companies which were in industries considered critical or strategic, which were manufacturing with sophisticated technologies, or which were predominantly engaged in exporting. Many multinationals responded to FERA by simply choosing to pull out of India, and of the 881 which stayed, only 150 of them were permitted to retain greater than 40 percent foreign equity.

Clearly, the three aspects of India's closed technology policy were not all implemented

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[4]Recent theoretical research by Cohen and Levinthal (1989) has shown that--assuming a weak patent regime promotes spillovers and that such spillovers are complementary to firms' own R&D--it is possible that a weak patent regime actually has the net effect of stimulating R&D overall. Such arguments are very recent, however, and the standard claim has been that a weaker patent regime will reduce appropriability and lower R&D.

[5]The Paris Convention requires that countries provide the same patent protection to domestic and foreign inventors: however, India has never signed the Paris Convention.

at once, and a multiplicity of objectives underlies the adoption of each feature. As a result, it was only for a relatively short period of time, from 1974- 1979, that the technology licensing regulations, the weak patent regime, and the FERA regulations on FDI were all in force together.

C. Gradual Liberalization: 1980 to the Present

India's lackluster export performance and the crisis brought about by the OPEC oil shocks provided a stimulus to greater liberalization during the 1980s as announced in the government's Industrial Policy Statements of 1980 and 1982. There was a loosening of the industrial capacity licensing regulations and the restrictions on imports of goods. More flexibility on the 40 percent ceiling for FDI was introduced, and 100 percent foreign ownership was allowed in export processing zones. The restrictions on technology licensing agreements were also relaxed, the number of contracts approved annually almost tripling in the 1980s as compared to the 1970s.

In spite of these reforms, the foreign exchange crisis persisted and the Indian government introduced a dramatic set of changes in its New Industrial Policy of July, 199 I. Import barriers for goods were lowered further, and capacity licensing was abolished for about 80 percent of Indian industry. Foreign equity participation ceilings were raised from 40 to 5 1 percent in a wide range of industries, and the bureaucratic procedures for FDI were simplified. Technology licensing controls were loosened so that contracts receive automatic approval in priority sectors as long as royalty payments do not exceed 5 percent of domestic sales or 8 percent of export sales. In the first six months of the New Industrial Policy, 505 TP agreements were approved, as compared with *annual* averages of 270 and 730 in the 1970s and 1980s respectively. In spite of the liberalization of the regulations on FDI and TP contracts during the past decade, there has been no strengthening of India's patent regime. This is in spite of the fact that the United States has put enormous pressure on India to offer greater patent protection, threatening to impose trade sanctions on India through the exercise of Section 301 of the U.S. Trade Acts of 1984 and 1988. Further pressure on India to strengthen its patent regime may result from accords reached al the Uruguay Round of the GATT negotiations.

D. The Lessons of History

The rhetoric of "self-reliance" has often been used to generate public support for the various aspects of India's closed technology policy, but the historical record suggests that it was foreign exchange crises which appear to have provided the actual stimulus for the adoption of such policies. Indeed, while "self-reliance" was a prominent theme from the time of independence, it was not until 1974, after several foreign exchange crises, that all three aspects of India's closed technology were finally implemented. Furthermore, two of the three features were rapidly relaxed in 1980 when it was felt that doing so would alleviate another round of foreign exchange problems. Apparently, the long-run goal of "self-reliance" has frequently been given less priority than the immediate crises at hand.

The fact that Indian technology policies have been more short-sighted and pragmatic than is commonly assumed reveals a dangerous tendency which must be avoided if the current reform process is to be sustained. Various aspects of the economic reforms announced by the Indian government in 1991 will undoubtedly be disruptive and painful, and there will be pressures to slow or even reverse the present course. Indeed, current pressures on the federal budget are already threatening the reform process. Since regulating the activities of foreigners is often politically appealing and frequently appears to save on foreign-exchange in the short-run, Indian policymakers will undoubtedly be tempted--as they have in the past--to revert to restrictions on

FDI and on TP licenses. Such temptations must be resisted, for as we shall see below, it appears that there are substantial increases in growth which can be achieved from abandoning the closed technology policy. In addition to its intrinsic value, such growth will have the additional benefit of expanding the tax base and alleviating the current pressures on the federal budget, thereby helping the reform process to continue.

However shortsighted the actual motivations of the various actors in the Indian government may have been, it remains the case that promoting indigenous innovative activity through restricting access to foreign technology is an idea with considerable appeal to many economists in India and elsewhere. Hence, it is important to ask the question: Under what conditions, if any, would thc thrcc features of India's closed technology policy---the weak patent regime, the restrictions on TP licenses, and the regulation of FDI--raise social welfare? Answering this question is the focus of the next section.

III. The Effects of a Closed Technology Policy on Social Welfare

A. Optimal Patent Policies for LDCs

The arguments for patent protection in developed countries are quite familiar. Because inventors are unable to appropriate all of the returns from their R&D, patent protection assigns to them a temporary monopoly right in exchange for their revealing their inventions to society as a whole. As a result of the patent protection, there should be more inventions produced than would be the case without such protection, and this increase in inventions should improve society's welfare.

The issues for LDCs are somewhat different for two distinct reasons. First. because LDCs have a comparative disadvantage in the production of new ideas, granting nondiscriminatory patent protection to foreign and domestic inventors, which raises the price which the inventors can charge for their inventions, is equivalent to reducing the terms of trade for the LDC. Second, due to LDCs' low income levels, the market for an invention in any given LDC is usually small relative to the entire market for that invention worldwide. Hence, whether or not a developed country firm invests in discovering a new technology is primarily determined by the firm's ability to appropriate the returns from that technology in the markets of countries other than the LDC in question. As a result, if the LDC strengthens its patent protection for foreigners. it will do very little to stimulate the development of any more foreign technologies. Taken together, stronger patent protection for foreigners seems to imply higher costs and no benefits for LDCs.

A formal treatment of these considerations can be found in the theoretical analysis of Diwan and Rodrik (1989), who use a two-country model in which all innovations are produced in the developed country, but the developed country and less developed country may have different preference8 over the types of innovations which are produced. For example, consumers in the LDC might have a greater preference for technology concerned with tropical diseases than the consumers in the developed country. Diwan and Rodrik allow for an infinite range of potential new innovations which may be discovered and sold, with consumers in the developed and less developed countries having a distribution of preferences over this range of potential

[6]The term "preferences" should be taken broadly to include any peculiarities between the foreign and domestic markets, not just differences in consumers' tastes. For example, the types of production processes needed to produce a given good may be very different between the developed and less developed countries due to climactic, market, or other environmental conditions. In such a case, the developing country may have very different "preferences" for the type of technologies developed for reasons which have nothing to do with consumer tastes.

innovations. The subset of all the potential innovations which actually gets developed is endogenous in their model, being determined by the two countries' sizes, the levels of patent protection in each, and the differences in the countries' preferences.

When the countries have similar preferences, it is usually in the interest of the LDC to offer very little patent protection, free-riding on the spillovers from the developed country, However, when the countries have very different preferences, the LDC has an incentive to offer protection, for this results in the development of more of the technologies which the LDC prefers than would be developed otherwise.

The intuition for the Diwan and Rodrik results is clear. When preferences are different between the two countries, there will be potential new innovations for which the LDC is a large fraction of the total market for the new innovation, implying that the LDCs' patent policies have more leverage in determining whether or not investing in developing the new innovation is profitable. Tn such cases, if the LDC does not provide patent protection, it may lower the potential returns from the innovation sufficiently to prevent the innovation from being developed, costing the LDC the loss in consumer surplus from not having the product available.

The theoretical models of Chin and Grossman (I 988) and Subramnnian (199 I) yield results similar to those of Diwan and Rodrik (1989) about the likely benefits to LDCs of offering weak patent protection to foreigners. However, the underlying assumption in all three of these papers is that a weaker patent regime allows for greater access to free foreign technology through spiilovers. At first glance this seems like an innocuous assumption, since weaker patent protection provides greater scope for copying foreign technology without fear of prosecution for violating property rights. At the same time, a stronger patent regime will induce foreigners to increase their FDI, exports, and technology sales in India. If--as many expect-- there is a positive demonstration effect from such increased foreign activity on Indian soil, then a stronger patent regime may actually increase the total spillovers.[7]

Perhaps even more important is that the models reviewed here fail to consider the impacts of punitive measures which developed countries might inflict on those LDCs which fail to provide adequate patent protection. It may be less costly for the LDC to simply comply with the foreign requests for greater patent protection than to face the effects of such punitive measures. Indeed, this appears to be the course that many LDCs are taking under intense pressure from the United States and other developed countries.

In summary, the available theoretical models generally conclude that providing weak patent protection for foreigners is the optimal policy for LDCs, while offering stronger protection for domestic inventors may be desirable. However, these results must be qualified by the considerations mentioned above concerning demonstration effects, differences in preferences for inventions, and developed country retaliation. In short, until there is more evidence about such factors, it is not clear what the optimal patent policies are.

B. Optimal Technology Import Policies

Why would a country ever want to place a tax on imports of technology from other countries'? At first glance such a policy seems counterproductive for a country which is trying to increase its technological capabilities; however, this section will demonstrate that a tax (subsidy) on TP will be welfare-improving whenever R&D and TP are substitutes (complements)

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[7]My thanks to Rakesh Basant, Robert Evenson, and Richard Levin for making this point to me.

in the production of knowledge as long as the social return to R&D exceeds the private return. If it is also the case that the social return to TP exceeds its private return, then the results may be reversed.

There are a variety of contexts, regardless of the market structure, in which the social return to R&D exceeds the private return, causing a laissez-faire economy to underinvest in R&D, where "underinvest" is taken in the usual economic sense to mean investing below the levels which will maximize the social welfare function.[8] First, whenever there are R&D spillovers between firms, the marginal social returns to R&D will exceed the marginal private returns, resulting in an underinvestment in R&D levels. Second, even when there are no spillovers, if there is learning-by-doing in R&D within the firm and the social discount rate is lower than the private discount rate there will be an underinvestment in R&D. Third, there may be strategic or political reasons' for the Indian government to want to develop a corps of domestic scientists with research capabilities. In a time of war, for example, access to foreign technology might be cut off so that having a pool of domestic talent with R&D experience could prove quite valuable. The public-good aspect of such strategic or political motivations is likely to result in an under-representation of these preferences in the private sector alone, resulting in

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'There are a variety of scenarios in which the pre- or post-innovation, market structure will cause an underinvestment in R&D from a societal point of view (see Tirole (1988)). In the present discussion we ignore these market structure distortions and focus on a case in which firms are initially in a perfectly competitive environment and have upward-sloping, marginal cost curves and u-shaped, average cost curves. An innovation for a particular firm will lower its marginal and average costs, but because the firm is small relative to the size of the market, perfect competition prevails even after the innovation.

'These are sometimes referred to as "noneconomic objectives." See Bhagwati and Srinivasan (1983) chapter 24.

an underinvestment in R&D.

It is quite easy to show that if the social return to R&D exceeds the private return, an R&D subsidy is the welfare-maximizing strategy. However, it might be argued that this policy instrument cannot be employed very effectively because it is very difficult to observe firms' R&D, and firms obviously have an incentive to overstate their R&D expenditures if the government has subsidies in place. Furthermore, in the context of an LDC, the revenues necessary to finance a subsidy may be especially costly to collect.

Hence, in this section it is assumed that the government can only tax or subsidize TP, since there are several reasons that these policies should be easier to implement than the R&D subsidy. First, TP contracts are much more visible than R&D expenditures. Because TP contracts must be negotiated with foreign firms and approved by the Indian government in order to get the required foreign exchange, they are necessarily out in the open. Second, in order to cheat, a domestic firm would have to obtain the cooperation of the foreign firm to trick the Indian government during the contract approval process, a feat which is inevitably more difficult than cheating on one's own. Finally, providing subsidies to R&D requires that the government raise the offsetting revenues from some other place. Such a problem is not present with a tax on TP, which, as shall be seen below, is a welfare improving policy as long as R&D and TP are substitutes.

Consider an industry with N identical firms, all of which are price takers with regards to output and the two inputs, R&D and TP. The production function from each firm i's perspective is given by:[10]

$$F^i = F^i(RD_i, TP_i) \tag{1}$$

where RD_i and TP_i are the R&D and TP employed by firm i. Because the firms are identical, the i subscripts and superscripts can be dropped, and N can be normalized to equal 1. The shape of the production function is assumed to satisfy the following:

$$\begin{gathered} F_R > 0,\ F_T > 0, \\ F_{RR} < 0, \quad F_{TT} < 0, \\ F_{RT} <> 0 \end{gathered} \tag{2}$$

where the subscripts denote the partial derivatives with respect to the stated variables. Notice from the last term that it is not specified a priori whether or not RD and TP are substitutes (F_{RT} c 0) or complements (F,, > 0) in production.

The firms will maximize their profits, π, by choosing RD and TP, taking the prices of output, RD, and TP as given:

$$\max \pi = F(RD,TP) - p_R RD - (p_T + t_T)TP \tag{3}$$

where p_R and p_T denote the prices of RD and TP respectively in terms of numbers of units of output, and t_T is the tax or subsidy per unit of TP. The first order conditions for the optimal choice of RD and TP are:

$$\begin{gathered} \delta\pi/\delta TP = F_T - p_T - t_T = 0 \dashrightarrow F_T = p_T + t_T \\ \delta\pi/\delta RD = F_R - p_R = 0 \dashrightarrow F_R = p_R \end{gathered} \tag{4}$$

[10] We could also include a vector, X, of traditional inputs such as capital, labor, and materials. However, government regulations implied that firms in India had little control over the levels of such inputs, so including them here unnecessarily complicates the analysis. See Fikkert (1994a) for a detailed description of these regulations.

It is assumed that the social value of R&D exceeds the private value by the amount **W(RD).** where $W_R >= 0$ and $W_{RR} =< 0$.[11] Hence. in an economy with private ownership a social planner would maximize total welfare, **V(RD,TP)**, by choosing RD, TP, and t_T to solve:

$$\max V(RD,TP) = F(RD,TP) + W(RD) - p_R RD - p_T TP \tag{5}$$

knowing that firms will choose RD and TP according to the equations in (4); hence, the Lagrangian for the social planner can be expressed as follows:

$$L = F(R,T) + W(R) - p_R R - p_T T - \lambda(F_T - p_T - t_T) - \eta(F_R - p_R) \tag{6}$$

where λ and η are the Lagrange multipliers for the constraints imposed by the equations in (4). Solving the first order conditions of equation (6) and solving for t_T yields:

$$t_T = F_{TR} W_R / F_{RR} \tag{7}$$

Now F_{RR} is less than zero and W_R is greater than zero, Hence, if R&D and TP are substitutes so that F_{TR} is less than zero, t_T is positive, implying that the optimal policy is indeed a tax on TP. On the other hand, if F_{TR} is greater than zero so that R&D and TP are complements, then t_T is negative, implying that the optimal policy is a subsidy on TP.

Of course, it is very unlikely that the government would ever have sufficient information to calculate the optimal level of the tax on TP in equation (7). Fortunately, it is possible to show that a small tax increase on TP will be welfare improving over the laissez-faire situation when R&D and TP are substitutes (see Fikkert (1994a) for details).

It is important to note that all of the above analysis has assumed that externalities emanate from R&D but not from TP. This is the same as assuming that operating foreign technology on

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[11] Later, we shall also consider the case where the social value of technology purchase exceeds the private value.

domestic soil does not increase the spillovers from that technology due to demonstration effects. There is very little evidence on the extent of such demonstration effects, but it is frequently argued that such effects are important. Hence. in addition to the R&D externality, we now add the assumption that the social benefits of TP exceed the private benefits by the amount **X(TP).** If all instruments were available, subsidies on both R&D and TP would be the optimal strategy. However. if only a tax or subsidy on TP is available, it is simple to show that the expression in equation (7) becomes:

$$t_T = F_{RT}W_R/F_{RR} - X_T \tag{8}$$

Note that equation (8) is identical to the optimal tax in equation (7) except that the optimal tax is reduced by the marginal effect of the TP externality, X_T. We have already seen that when R&D and TP are substitutes, $F_{RT}W_R/F_{RR}$ is positive. Hence, as long as X_T is not too large relative to $F_{RT}W_R/F_{RR}$, i.e. the TP externality is not too large relative to the R&D externality, the best strategy is a tax on TP when R&D and TP are substitutes and no R&D subsidy is available. If R&D and TP are complements, then t_T is unambiguously negative, implying that the optimal policy is a subsidy on TP. Unfortunately, there is no empirical evidence on the relative magnitudes of R&D and TP externalities; thus, while a TP tax could be welfare-improving in principle, there is little evidence on which to base such a conclusion. More about this will be discussed in the empirical section below.

C. Optimal FDI Regulations

Because FDT is a complex package of foreign technology, financing, management, and control which is often part of the parent company's global corporate strategy, there are a host of issues surrounding the costs and benefits of FDI in LDCs. This debate is far too extensive to be reviewed here, and this section focuses on FDT only as it relates to the technology policy issues of interest in this study.

As will be described further below, Fikkert (1994b) finds evidence that firms with histories of FDI appear to have lower search and transactions costs for buying foreign technology, such firms often purchasing technology from their former parents. In addition, he finds that there is a positive direct effect of a history of FDI on R&D. The exact reason for this is not clear, but it may be that firms with FDI histories have better access to financing for R&D, providing a direct stimulus to the amount of R&D performed. Another possibility is that firms with **FDI** histories have foreigners present with valuable R&D **experience,** making the R&D in such firms more productive.

Using minor extensions to the model outlined in the previous section, Fikkert (1994a) examines the optimal **R&D** and **TP** subsidies and taxes which would prevail if **FDI** lowers the cost of technology purchase, reduces the costs of financing R&D, and/or raises the productivity of performing R&D. When, as is assumed in the previous section, the social returns to R&D and/or **TP** exceed their private returns, it is possible to show that the optimal levels of subsidies and taxes on R&D and/or TP are different for firms with FDI histories. However, in none of these scenarios is there any justification for the overall limits on FDI which the Indian government has employed. While there may be other legitimate reasons for such comprehensive regulations, from the perspectives analyzed here only different taxes and subsidies for firms with FDI are needed.

In summary, while there are conditions under which weak patent protection and a tax on

TP might be welfare improving, there are equally plausible conditions under which such policies would reduce welfare; hence, there is no clear theoretical, justification for promoting government intervention of the type seen in India. However, there is certainly a need for more empirical evidence on these issues, some of which is provided in the next two sections.

IV. The Effects of a Closed Technoloav Policy on R&D

The welfare issues discussed in the previous section are not the only points of contention surrounding India's technology policies, for many have doubted whether these policies achieved even their limited objective of stimulating domestic R&D. Unfortunately, there is very little evidence on even this more limited question. Up until very recently, there do not appear to have been any systematic empirical studies on the effects of weak patent regimes or FDI on LDC firms' innovative efforts. With regards to the effects of the TP regulations, there are a number of empirical studies purporting to show that foreign TP stimulates domestic R&D: however, this TP literature appears to be flawed at both the conceptual and empirical levels.

At the conceptual level, the TP literature has cited the findings of numerous case studics[12] that forcign tcchnology--particularly that which is cmbodied in purchased inputs--provides a stimulus to local R&D because of the need to adapt foreign technology to local conditions. While there is undoubtedly a need to perform such adaptive R&D, there are at least two other factors which may cause TP licenses to substitute for firms' R&D expenditures. First, in contrast to the embodied technology which the firm implicitly purchases when it imports

[12]See, for example, the case studies by Bhagwati and Srinivasan (1975); Desai (1980), (1984); NCAER (1971); and Lall (1987).

production inputs, the technology purchased through TP licenses is disembodied and supplies the firm with explicit instructions detailing the basic design, and know-how for implementing some new technology. Hence, a firm which purchases technology through a TP contract dues not have to perform R&D to develop this basic design and know-how on its own. Second, the unit costs of R&D and TP may rise with the level of total expenditures on innovation--the sum of R&D and TP expenditures--due to either internal costs of adjustment to new technology or to increasing financing costs. If this is the case, then each rupee spent on TP raises the shadow price of R&D, tending to lower the quantity of R&D demanded. Indeed, a careful- reading of the case study literature reveals that both of these factors were observed in Indian firms,[13] at least partially offsetting the positive stimulus to R&D created by the need to adapt foreign technology to local conditions.

Citing the case-study evidence about the adaptive nature of domestic R&D, several empirical studies have found that foreign TP appears to stimulate domestic R&D expenditures. However, these studies suffer from several shortcomings. First of all, with the exception of Deolalikar and Evenson (1989), all of the existing studies of which the author is aware treat either R&D or TP expenditures as an exogenous variable, subjecting the estimates to the problem of simultancity and preventing any conclusions to bc drawn about the true relationship between these two variables (Braga and Wilmore (1991); Katrak (1985), (I 989), (1990), (199 1); Kumar (1987); Mohnen and Lepine (1987)). Furthermore, because most firms in India choose to perform no R&D and/or to buy no technology, the firms used in such studies are frequently chosen because they are known to engage in such activities (Katrak (1985), (1989), (1990).

'"See Fikkert (1994a) for details.

(199 I)), raising the problem of endogenous sampling and providing an additional source of bias.

Deolalikar and Evenson (1989) recognize the problem of simultaneity, estimating a two-equation demand system in which both Indian innovative efforts and foreign TP are endogenous variables: however, because they do not have separate prices for R&D and TP, they fail to identify how these two variables interact. Furthermore, their use of industry-level data is problematic because aggregation may mask relationships at the firm level.

Fikkert (1994b) attempts to shed some light on the effects on R&D of all three features of India's closed technology policy using panel data from 571 large and medium Indian firms for the period 1975-76 to 1978-79. [14] Fikkert assumes that there are three basic ways for a firm to acquire new technology: 1) invent the new technology on its own through R&D; 2) purchase the new technology through TP licenses, and 3) pirate the new technology from foreign or domestic spillovers. Firms then choose an optimal amount of R&D and TP in the presence of international and domestic spillovers in order to maximize the present discounted value of the stream of future profits. Kuhn-Tucker conditions need to be applied to this maximization problem, for as Table I indicates roughly 90 percent of the observations in Fikkert's sample are corner solutions, i.e. cases in which firms choose zero amounts of R&D and/or TP. Firm's choices of R&D and TP take on the following basic form:

$$RD^* = \beta_R \mathbf{TP} + \gamma_R \mathbf{X} + \mathbf{e}_{Rt} \tag{9a}$$

$$\mathbf{TP}_* = \beta_T \mathbf{RD} + \gamma_T \mathbf{X} - g + \mathbf{e}_{Tt} \tag{9b}$$

and

[14] During this period, all three features of India's closed technology policy were in place.

$$RD = RD^* \text{ iff } RD^* > 0 \qquad (10)$$
$$= 0 \text{ iff } RD^* <= 0$$

$$TP = TP^* \text{ iff } TP^* > 0 \qquad (11)$$
$$= 0 \text{ iff } TP^* <= 0$$

where **X** is a vector of exogenous variables including international and domestic R&D spillovers and a dummy indicating if the firm has a history of FDI; g represents the strength of the government's TP regulations, which vary across industries; and e_{Rt} and e_{Tt} are error terms. The facts that g does not enter the equation for RD* and that there are a number of cross-equation and parameter restrictions are sufficient to identify the parameters of the model, which is estimated using maximum-likelihood techniques.

Table 1

NUMBERS OF OBSERVATIONS ACROSS R&D AND TP CASES[15]
Percentages in Parentheses

CASES	ALL FIRMS	SCIENTIFIC FIRMS	NONSCIENTIFIC FIRMS
Case 1: RD > 0, TP > 0	199 (X.7)	X4 (10.2)	115 (7.9)
Case 2: RD > 0, TP = n	619 127.1,	313 (38.0)	306 (21.0)
Case 3: RD = 0, TP > 0	216 (9.5)	74 (9.0)	142 (9.7)
Case 4: RD = 0, TP = 0	1250 (54.7)	353 (42.8)	897 (61.4)
Totals	2284 (100.0)	x24 (100.0)	1460 (100.0)

[15] "Scientific Firms" refer to firms in those industries usually considered to be more technologically dynamic: chemicals, drugs, and electronics. "Nonscientific Firms" refers to firms in all other manufacturing industries for which data were available: non-electrical machinery, transportation, non-metallic minerals, paper, sugar, rubber, metals, and textiles. See Griliches and Mairesse (1984) for a similar grouping.

Because both R&D and TP are treated as endogenous variables, it is possible to avoid the simultaneity issues which plague previous studies and to address properly the effects of India's regulations on TP licenses. In addition, since one of the explanatory variables in both equations is an indicator for whether or not the firm has a history of foreign equity participation, it is possible to examine the effects of India's regulations on FDI on R&D. Finally, the inclusion of domestic and international spillover variables sheds some light on the effects of India's weak patent regime.

The results indicate that, contrary to previous findings, β_R is negative, indicating that foreign TP substitutes for R&D expenditures. In this light, India's restrictions on TP licenses, which raise g in equation (9b), lower TP and then raise RD due to the fact that β_R is negative. Hence, India's TP restrictions appear to have provided the government's desired stimulus to indigenous R&D. However, as we shall see in the policy simulations below, due to the prevalence of corner solutions detailed in Table 1, the overall stimulus to domestic R&D was quite small.

The estimates also indicate that FDI provides a positive, direct effect on R&D due either to such firms having more productive R&D or to such firms having access to cheaper financing for R&D investments. However, FDI also appears to lower the search and transactions costs of TP, FDI having a positive, direct effect on TP which then lowers R&D through the negative coefficient, β_R For the scientific firms, the negative, indirect effect dominates, implying that FDI has the net effect of lowering firms' R&D expenditures, while for the nonscientific firms the opposite is true. However, once again simulations demonstrate that the effects are very small for both sets of firms.

Finally, both foreign and domestic R&D spillovers appear to provide a positive stimulus to each firm's R&D, presumably because they provide opportunities for reverse engineering and follow-on improvements. The positive effect of the spillovers seems to suggest that a weak regime. which permits copying of the R&D of others, promotes indigenous R&D; however, there are two important caveats to be noted. First, the positive effect of spillovers is mitigated somewhat by the usual negative impact on R&D of imperfect appropriability. In this light, the most effective patent regime for promoting indigenous R&D may be one which provides weak patent protection for foreigners and strong protection for Indians. Such a policy would permit foreign spillovers to stimulate domestic R&D and remove the negative impact of imperfect appropriability. Second, while the estimates here suggest that spillovers promote R&D, it is actually not clear whether a weak patent regime promotes or reduces international spillovers. As mentioned earlier, a stronger patent regime should increase foreign firms' activity on Indian soil, possibly demonstrating to Indian producers more about foreign technology and thereby increasing the total quantity of spillovers from that foreign technology. However, there is very little empirical evidence about the magnitude of such demonstration effects.

In summary, Fikkert (1994b) finds that the TP regulations did stimulate domestic R&D. Under the assumption that spillovers are increased by weak patent protection--which may not be the case if demonstration effects are sufficiently strong--the same result is true for the granting of weak patent protection for foreigners. Finally, the FDI regulations appear to have stimulated R&D in the scientific industries, while lowering R&D slightly in the nonscientific industries. As we shall see in the next section, policy simulations indicate that the strongest of the three policies were the TP regulations, implying that the overall effect of the closed technology policy was to stimulate indigenous R&D; however, the presence of comer solutions makes the elasticity of R&D with respect to each policy quite small.

V. Policy Simulations: The Effects of Liberaiization on R&D and Profits

As discussed in the previous section, there is evidence that abandoning the closed technology policy will result in a loss of R&D. But by how much *will* R&D fall, and what will he the effect of liberalization on profits and welfare? This section provides the results of policy simulations which will provide some insight into these questions. In conducting these simulations, we need estimates of both the determinants of R&D and TP and the effects of R&D and TP on output. Thc former estimates are obtained from the study of Fikkert (1994b), which was reviewed in the previous section. The latter estimates are available from Basant and Fikkert (forthcoming), who use the same firm-level data to obtain fixed-effects estimates of production functions in which R&D and TP are inputs along with the traditional factors of capital, labor, and materials. The most important result from their study is that in every specification, the effect of TP expenditures is large and significant while the effect of firms' own R&D is small and insignificant. The computed rates of return from their estimates are detailed in Table 2. The higher returns to TP imply that any policy reform which increases TP and lowers R&D, such as a removal of the TP regulations, will tend to increase firms' profits.

Table 2

Estimate Rates of Return to R&D and TP

	Complete Sample	Scientific Subsample	Nonscientific Subsample
Percentage Rate of Return to TP	126	168	98
Percentage Rate of Return to R&D	83	6	67

Note: These figures are taken from the fixed effects estimates with time dummies but without spillovers in Basant and Fikkert (forthcoming)

In order to understand the significance of the corner solutions for the outcomes of these policy simulations, it is necessary to consider that equations (9)-(11) indicate that a firm might fall into four possible cases, depending on whether R&D and TP are at interior or corner solutions (see Table 1). Moreover, the derivative of R&D with respect to any policy change is different across the four cases. For example, we see from the equations in (9) that for a firm which is initially in Case 1 (RD > 0, TP > 0) the derivative of RD with respect to the strength of the government's TP licensing regulations is:

$$\delta RD/\delta g = -\beta_R/(1 - \beta_R\beta_T) \tag{12}$$

It is possible to show that the denominator of this expression must be positive in order for profit maximization to hold, so the numerator is positive as long as β_R is negative, which Fikkert (1994b) finds to be the case. However, if the firm initially has chosen a corner solution for either RD or TP (Cases 2-4), the derivative of RD with respect to g is 0, implying that a change in g will only effect RD if it is sufficiently large to first move the firm into Case 1. It is this zero-derivative property combined with the prevalence of corner solutions detailed in Table 1 which results in very low elasticities of response of RD to the various policy changes.

The basic methodology employed in these simulations was to make random draws from the distributions of the errors terms in equations (9). Using these random draws, the estimated parameters, and the values of the exogenous variables in 1978, values of RD and TP were calculated according to equations (9)-(11). The government's policy parameters were then changed with respect to the technology licensing regulations, the patent protection for foreigners, and the FDI restrictions. Using the same random draws which were obtained in the previous step, new values of RD and TP were then computed for each firm, taking into account the effects of the change in government policy on each firm's optimal choices. For each firm we now have a flow of RD and TP in 1978 both before and after the change in government policy in that year. We then employed the fixed effects, production function estimates for the same firms obtained by Basant and Fikkert (forthcoming) in order to examine the marginal effects of the policy-induced changes in RD and TP on the present discounted value of profits (PDV), assuming an annual discount rate of 8 percent and growth rates of both 0 and 6 percent in firms' capital, labor, and materials inputs.[16,17] One hundred rounds of each set of simulations were conducted, a new pair of independent errors being drawn for each firm in each round. At the end of each round, the firms' endogenous variables (RD, TP, PDV) were summed to give the aggregate values of these endogenous variables.

A. Effects of Weakening the Technology Licensing Regulations

If the Indian government were to weaken its TP regulations, what would be the impact on R&D? We have already seen from the derivative in equation (12) that--for firms in Case 1 (RD > 0, TP > 0)--as long as β_R is negative, a fall in g will lower R. In fact, it is possible to show that when β_R is negative, a firm's R&D will not rise when g falls, regardless of which case the firm is in initially.[18]

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[16]For both the scientific and nonscientific subsamples, Basant and Fikkert (forthcoming) estimate a production function in which capital, labor, and materials are traditional inputs, and R&D, TP, and spillovers are knowledge inputs. Because their estimates without spillovers appear to be more reliable, we use these in the current paper, examining only the effects of different levels of RD and TP on output. See the fixed effects estimates with time dummies in Table 4 of Basant and Fikkert (forthcoming).

[17]The average annual growth rate in output for the firms in the data set was 6 percent for the period 1975-76 through 1979-80.

[18]See Fikkert (1994a) for a proof.

By how much will RD fall when g falls? To answer this question we simulate the effects of the Indian government's weakening of its TP licensing regulations sufficient to double the amount of firms' aggregate TP expenditures. In fact, the Indian government introduced such a policy in 1980, the number of technology contracts granted in the 1980s jumping to twice their pre-1980 level. Simulation 1 in Table 3 reports the means and t-statistics from such a loosening of the TP regulations. As predicted, when g is lowered, RD falls, but the response of **RD** is rather low, dropping by only 14 percent for the complete sample and by 9 percent and 17 percent for the scientific and nonscientific subsamples, respectively. However, due. to the higher productivity of TP than RD, for the complete sample of firms the present discounted value of private profits rises by 88.36 percent in the case of 6 percent growth in other inputs (PDV6). While the numbers are similar for the scientific firms, the estimates for the nonscientific firms indicate much larger gains in percentage terms of 168.8 percent in the case of 6 percent growth.

B. Effects of Strengthening the Patent Protection for Foreigners

There are several difficulties in assessing the impacts on R&D of changing patent protection for foreigners. First, while the direct effect of international spillovers seems to stimulate firms' R&D, it is not clear whether a stronger patent regime promotes or reduces aggregate foreign spillovers. As discussed earlier, if a stronger patent regime causes foreign firms to engage in more activities in India, and if such activities demonstrate more about foreign technology to Indian firms, then it is possible that a stronger patent regime will actually increase spillovers of foreign technology, promoting domestic R&D according to the estimates in this paper. Furthermore, a stronger patent regime may increase the amount of TP expenditures both because technology suppliers should be more willing to license technology which receives stronger protection and because Indian firms should be more willing to pay for technology which they can no longer pirate. If these effects of a stronger regime raise **TP,** they would put downward pressure on **RD,** because **RD** and TP arc substitutes. Unfortunately, it is not possible to capture all of these effects with the current estimates.

Because of all of these difficulties, we should be very hesitant about drawing conclusions from the estimates concerning the effects of adjusting the strength of the patent system. But for the sake of argument, let us make the standard assumption that a stronger patent regime for foreigners reduces international spillovers into India and that the indirect effects of strengthening the patent regime on RD through the TP equation are negligible. Then, the estimates in Fikkert (1994b) indicate that providing stronger patent protection for foreigners will reduce indigenous R&D.

Under these assumptions, by how much will RD fall when India offers stronger patent protection to foreigners? To answer this question we must first determine the extent to which international spillovers in India would fall when India strengthens its patent protection. This is clearly very difficult to predict, but it appears that the drop in spillovers would be very small due to low levels of patenting by foreigners in India. Consider that even under the relatively strong British patent regime which prevailed in India prior to 1972, only about 3-4 percent of the patents taken out in the developed countries were taken out in India, a figure which fell to about 2 percent in the weaker, post- 1972 regime. Hence, all else equal, even if India strengthened its regime to the pre- 1972 levels, this would raise the amount of foreign technology patented in India from 2 to 4 percent. To be generous, let us say that a rise to 6 percent of world patents taken out in India is achievable. Now even if the protection for the inventions patented in India were perfect so that a full 6 percent of the world's inventions could not be copied by Indians, this would only represent a reduction in spillovers of 4 percent from their previous levels (6 percent under the strong regime minus 2 percent under the weak regime). Low levels of foreign patenting in India give the Indian government very little leverage for controlling the size of the international spillover pool.

The effects of a 4 percent reduction in international spillovers are reported in Simulation 2 in Table 9. It is clear that the overall effects are very small, the drop in RD being less than 0.5 percent in all three sets of estimates. Because RD and TP are substitutes, the fall in RD induces a small rise in TP, causing a slight increase in the present discounted value of profits."

C. Effects of Loosening the Regulations on FDI

As discussed earlier, Fikkert (1994b) finds two affects of FDI on RD. First, there is a direct effect, which is estimated to be positive. Second, there is an indirect effect resulting from the fact that FDI lowers the search and transactions costs of TP, thereby causing RD to fall because RD and TP are substitutes. Depending on whether the direct or indirect effect is stronger and on which of the four cases a firm is in initially, FDI might raise R&D for some firms while lowering it for others. Indeed, this was the case for the firms in the present sample.

In order to quantify the aggregate effects of introducing more FDI, simulations were

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"Table 3 uses those estimates from Basant and Fikkert (forthcoming) which do not include international spillovers as a production input; hence, two effects on profits are overlooked in the computations in Simulations 2 and 4: 1) When international spillovers are reduced, the marginal productivity of an Indian firms' R&D is lowered, reducing output and profits below the level computed in Table 3; 2) There is potentially a positive, direct effect of international spillovers on output (although Basant and Fikkert (forthcoming) find such an effect to be insignificant), implying that when spillovers fall both output and profits will be lower than that computed in Table 3.

conducted in which firms initially without FDI were chosen at random to receive FDI, the probability of being chosen adjusted to cause approximately a 30 percent increase in FDI. As the results of Simulation 3 in Table 3 illustrate, introducing FDI raised RD for the complete sample and the nonscientific subsample, but lowered it for the scientific subsample. However, the effects on RD are very small in all three cases. For all three sets of firms, allowing greater FDI increased TP expenditures, causing slight increases in the present discounted value of profits.[20]

D. Effects of Abandoning the Closed Technology Policy

What is the overall effect of abandoning all three features of the closed technology policy simultaneously? The answer to this question obviously hinges on the extent to which each feature of the closed technology policy were changed. Hence, it is necessary to consider changes in policies which seem the most plausible in terms of their magnitude. As mentioned earlier, the Indian government relaxed its TP regulations in 1980, the result being a doubling of annual TP expenditures in the 1980s. Hence, there is historical precedent for the doubling of TP expenditures in Simulation 1. Similarly, rates of foreign patenting in India before and after the patent regime change in 1972 are known. As discussed earlier, the low levels of foreign patenting in India even under a strong regime suggest that increasing patent protection would reduce spillovers by at most 4 percent. Unfortunately, it is difficult to gauge the extent to which FDI could reasonably be expected to increase once FDI regulations were relaxed. In Simulation

[20]The production function estimates in Basant and Fikkert (forthcoming) do not examine the effects of FDI on the productivity of firms' R&D or TP, nor do they explore any direct effects of FDI on output. Hence, these simulations are only capturing the effects on output of FDI as it changes firms' levels of R&D and TP.

3, a reduction in FDI regulations sufficient to increase the number of firms with FDI histories by roughly 30 percent was considered. This seems to be a substantial increase; however, the 30 percent increase admittedly was chosen quite arbitrarily.

In light of these considerations. simulations were conducted in which the government policy parameters were held at the same levels as in Simulations 1-3. Sensitivity analysis was then conducted with respect to the percentage of FDI increase, the results indicating virtually no change from the figures for Simulation 4 in Table 3. It is clear that the abandonment of the TP regulations dominates the other two policies, the overall results being very similar to those of Simulation 1. R&D falls by 13, 11, and 16 percent for the complete sample, scientific subsample, and nonscientific subsample, respectively. This is matched by dramatic increases in the present discounted value of profits of 93, 78, and 170 percent for the complete sample, scientific subsample, and nonscientific subsample, respectively. Clearly, the private cost per unit of R&D "gained" under the closed technology policy is very high.

VI. Concluding Remarks

Is India sacrificing its long-run ability to innovate as part of the liberalization process? The estimates in Table 3 indicate that the answer to this question appeais to be "no" and that there may be substantial gains in productivity from opening up India's technology policies, The prevalence of corner solutions simply makes the loss of indigenous R&D from abandoning the closed technology policy very small, while the higher returns to TP makes the gains--at least in terms of private profits-- very large. In other words, the cost in terms of private profits per unit of R&D stimulated from maintaining the closed technology policy appear to be very high, Is abandoning the closed technology policy the optimal strategy? As discussed in Section III, the answer to this question is more complicated. There is some theoretical justification for maintaining weak patent protection for foreigners, but the current models overlook a number of important factors, including the possibility of demonstration effects and the costs of foreign punitive measures if India fails to strengthen its patent regime. In addition, at least for the issues examined here, there does not appear to be any justification for India's limitation of FDI. Finally, we come to the slightly more difficult case of the optimal strategy with respect to TP regulations. As the results in Section III demonstrate, when the social returns to R&D exceed the private returns by much more than the social returns to TP exceed the private returns, then a tax {subsidy) on TP is welfare-improving whcncvcr R&D and TP are substitutes (complements). The finding of Basant and Fikkert (forthcoming) and of Fikkert (1994b) that domestic R&D externalities exist indicates that the social benefits to domestic R&D do exceeds the private benefits, and both of these studies find that R&D and TP are substitutes. Present data does not allow an estimation of the extent to which the social benefits of TP exceed the private benefits of TP; hence, it is not possible to determine whether a TP tax is welfare improving or not.

However, there are several considerations which suggest that abandoning the TP regulations will be welfare improving as well. First, the available evidence indicates that the private returns to TP far exceed those to R&D. Hence, unless it is found that the difference between the social and private returns to R&D is much greater than the same difference for TP expenditures, imposing a tax on TP will be welfare reducing. Second, the presence of corner solutions for R&D and TP imply that the aggregate elasticity of response of R&D to any TP regulations is very small. As the simulations in Table 3 illustrate, what is a theoretical possibility is almost a moot point in reality. Finally, India's TP regulations have been far more bureaucratic and cumbersome than the simple tax on TP envisioned in Section III. Even if a TP tax were adopted, the dismantling of India's TP regulatory hierarchy is still a much needed reform.

Clearly, the issues surrounding the optimal set of technology policies are very complex, and given the lack of empirical evidence on several key parameters it would be premature to be too dogmatic. For the very same reasons, policymakers should be very hesitant about intervening so heavily in an area where so little is known. As this chapter has demonstrated, there is no clear theoretical justification for adopting any feature of India's closed technology policy. Furthermore, the empirical evidence indicates that doing so will do little to achieve even the more limited goal of "self-reliance" and will be very costly at least from the point of view of the private sector. It is likely that maintaining an open technology policy will help to generate the immediate growth necessary to make the current reforms sustainable.

Table 3

AGGREGATE RESULTS OF POLICY SIMULATIONS

(The mean value from 100 random draws)

	COMPLETE SAMPLE	SCIENTIFIC FIRMS	NONSCIENTIFIC FIRMS
Simulation : Loosening the TP Regulations			
(NEW TP) / (ORIGINAL TP)*	1.999 (78.37)	2.004 (28.98)	2.005 r lh.73)
(NEW RD) / IORIGINAL RD)*	0.860 (76.88)	0.906 (33.36)	0.833 (26.48)
Net Marginal Change in private PDV as % of Aggregate Profits **	56.61 (78.17)	43.63 (59.01)	101.6 (134.0)
Net Marginal Change in private PDV6 as % of Aggregate Profits **	88.36 (78.90)	67.31 (59.00)	168.8 (139.2)
Simulation 2: Strengthening Foreign Patent Protection			
(NEW TP) I (ORIGINAL TP)*	1.007 (34.42)	1.008 (25.32)	1.003 (15.39)
(NEW RD) I IORIGINAL RD)*	0.998 (59.99)	0.995 (55.45)	0.998 (24.37)
Net Marginal Change in private PDV as % of Aggregate Profits**	0.706 (27.62)	0.570 (22.94)	0.389 (18.42)
Net Marginal Change in private PDV6 as % of Aggregate Profits**	1.077 (27.45)	0.836 (22.11)	0.617 (1X.52)
Simulation 3: Loosening the FDI Restrictions			
Actual Number of Firms with histories of FDI in Sample	151	91	60
% Increase in Finns with FDI**	31.08 (70.94)	31.63 (68.79)	31.08 (43.90)
(NEW TP) / (ORIGINAL TP)*	1.018 (14.64)	1.080 (15.94)	1.001 (4.60)
(NEW RD) I (ORIGINAL RD)*	1.013 (26.87)	0.995 (7.51)	1.002 (4.60)
Ncr Marginal Chnnge in private PDV as % of Aggregate Profits**	1.068 (7.56)	0.389 (13.73)	0.107 (3.61)
Net Marginal Change in private PDV6 as % of Aggregate Profits**	1.770 (8.04)	0.601 (13.74)	0.215 (4.64)
Simulation 4: Abandoning a Closed Technology Policy			
Actual Number of Firms with histories of FDI in Sample	151	YI	60
% Increase in Firms with ml**	31.08 (70.94)	31.63 (68.79)	31.08 (43.90)
(NEW TP) / (ORIGINAL TP)*	2.100 (34.78)	2.176 (28.16)	1.947 (17.50)
(NEW RD) / (ORIGINAL RD)*	0.867 (62.88)	0.891 (40.12)	0.839 (27.63)
Net Marginal Change in private PDV as % of Aggregate Profits**	59.35 (76.65)	50.38 (62.91)	102.0 (132.8)
Net Marginal Change in private PDV6 as % of Aggregate Profits**	92.75 (77.38)	77.70 (62.89)	lhY.7 (138.5)

Note: This table is taken from Pikken (1994b).

* Figures in parentheses next to estimates are t-statistics for the difference between the estimated ratio and 1.

** Figures in parentheses next to estimates are t-statistics for the difference between the estimated number and 0.

All t-statistics significant at .01 level.

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